E906 Hodoscope Work Plan

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19 January 2007

1 Introduction

In order to realize the goals of the E906 experiment the scintillator hodoscopes from the E866 spectrometer will be refurbished with new material (scintillator and light guides) and double-ended readout will be added to the Station 3 and 4 hodoscopes. There are several reasons for these upgrades:

1. The scintillating material in these hodoscopes is old. Stations 3 and 4 were originally built for E605 in 1982. The scintillator in Station 2 is from 1989, and an examination of scintillator left over from that installation show signs of crazing. Significant decreases in efficiency were observed during E866/NuSea for several individual hodoscopes elements. This is presumably due to effects of aging. An additional 10 years will have passed since the E866 measurements, compounding this problem.
2. Station 1 is of insufficient size and hence would limit the experimental acceptance.
3. Double-ended readout of Stations 3 and 4 will provide for better timing and allow the experiment to handle higher rates.
4. This upgrade will allow more uniform geometry which will help with triggering.

Table 1 lists the number and division of the Hodoscope counters in each station. The upgrade of these hodoscope arrays (WBS 2.1) is divided into three parts. The upgrade of Stations 1 and 2 (WBS 2.1.2) will be led by the University of Illinois with primary

Table 1 This table list the number of counters and photomultiplier tubes for each Station in the E906/Drell-Yan spectrometer

Station	Division of Counters		Total Counters	Total Phototubes
	x	y		
X1	16	2	32	32
Y1	2	16	32	32
X2	16	2	32	32
Y2	2	16	32	32
X3	16	2	32	64
X4	16	2	32	64
Y4a	2	16	32	64
Y4b	2	16	32	64
Total 1, 2			128	128
Total 3, 4			128	256
Totals			256	384

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funding from the National Science Foundation (NSF). The manager of this part of the project is Prof. Naomi C. R. Makings. The upgrade of Stations 3 and 4 (WBS 2.1.3) will be led by Abilene Christian University with primary funding from the Department of Energy, Office of Nuclear Physics (DOE/ONP). The manager of this part of the upgrade is Prof. Rusty Towell. The new hodoscopes will reuse photomultiplier tubes from the E866 spectrometer, supplemented with photomultiplier tubes from the ZEUS detector at DESY. Quality control for these the recovered phototubes (WBS 2.1.1) will be done by the groups that will be using the tubes. This document provides details on the people and resources needed for this upgrade.

2 WBS

The detailed Work Breakdown Structure for the upgrade of the Hodoscopes is given below. In the sections following this, details about the cost, schedule and effort for these items will be given.

- 2.1. Hodoscope Upgrades
  - 2.1.1. Phototube quality control
    - 2.1.1.1.Construct photomultiplier test facility
    - 2.1.1.2.Test ZEUS photomultiplier tubes
    - 2.1.1.3.Test E866/NuSea photomultiplier tubes
  - 2.1.2. Station 1 and 2 hodoscopes
    - 2.1.2.1.Machine and polish HERMES scintillator
    - 2.1.2.2.Purchase light guides
    - 2.1.2.3.Hodoscope assembly
      - 2.1.2.3.1. Scintillator, light guide and photomultiplier assembly
      - 2.1.2.3.2. Wrapping hodoscope units
      - 2.1.2.3.3. Light-leak checking
      - 2.1.2.3.4. Efficiency quality control
    - 2.1.2.4.Hodoscope mounting in experimental hall
    - 2.1.2.5.Quality control checks *in situ*
  - 2.1.3. Station 3 and 4 hodoscopes
    - 2.1.3.1.Scintillator purchase
      - 2.1.3.1.1. Order material
      - 2.1.3.1.2. Receiving material quality control
    - 2.1.3.2.Light guide purchase
      - 2.1.3.2.1. Order material
      - 2.1.3.2.2. Receiving material quality control
    - 2.1.3.3.Hodoscope assembly
      - 2.1.3.3.1. Scintillator, light guide and photomultiplier assembly
      - 2.1.3.3.2. Wrapping hodoscope units
      - 2.1.3.3.3. Light-leak checking
      - 2.1.3.3.4. Efficiency quality control
    - 2.1.3.4.Hodoscope mounting in experimental hall
    - 2.1.3.5.Quality control checks *in situ*

3 Station 1 and 2 Upgrade

The upgrade of Stations 1 and 2 will be done by the University of Illinois, managed by Prof. Naomi C. R. Makins, and funded by the NSF. This part of the upgrade will use scintillator material recovered from the HERMES muon hodoscopes, which were built by Illinois. The material will need to be re-cut and polished to match the correct dimensions needed for the triggering requirements of the experiment. New light guides will be fabricated to match the new dimensions of the scintillators.

3.1 Cost

The cost of re-cutting and polishing the HERMES material was estimated based on the difference between purchasing rough cut and diamond milled scintillator. Additional cost include material for gluing jigs, wrapping materials, etc. (WBS 2.1.2.3) and modifications of E866/NuSea mounting stands (WBS2.1.2.4). These costs are listed Table 2.

3.2 Schedule and Effort

Work on the Station 1 and 2 hodoscopes will begin after the muon hodoscopes are removed from the HERMES experiment and are returned to Illinois. This will be in the fall of 2007 or winter of 2008. The effort needed to complete (*i.e.* after the material is machined and polished—see cost above) the hodoscope upgrade is estimated to be about 8 person-months. This work will be completed by graduate student(s) from the Illinois. Support for these students will be paid from the NSF grant to Illinois.

3.3 Primary Location of Effort

This work (up to WBS 2.1.2.5) will be done either at Illinois or at Fermilab. The counters are of such size that the can be readily handled and moved with minimal risk. Note that they will receive quality assurance checking once on site at Fermilab (WBS 2.1.2.6).

4 Station 3 and 4 Upgrade

The upgrade of Stations 3 and 4 will be done by Abilene Christian University, managed by Prof. Rusty Towell, and funded by the DOE/ONP. This part of the upgrade will use new scintillator material and light guides. In previous Drell-Yan experiments (*e.g.* E866 and E772) Abilene was also responsible for the hodoscope arrays.

Table 2 Material cost and effort for Station 1 and 2 hodoscopes

			Additional Effort (FTE)	
WBS	Description	Material Cost	Student	Senior Staff
2.1.2.1	Scintillator machining and polishing	$8k	2 wk (QA)	
2.1.2.2	Light guide purchase	$7k	2 wk (QA)	
2.1.2.3	Hodoscope assembly	$2k	4 months	2 months
2.1.2.4	Hodoscope installation	$10k	2 months	
2.1.2.5	Final Testing		1 month	
Totals		$27k	8 months	2 months

4.1 Material Costs

The primary material cost is the cost of the scintillator and light guide material. Additional costs include material for gluing jigs, wrapping materials, *etc*. (WBS 2.1.3.3) and modifications of E866/NuSea mounting stands (WBS2.1.3.4). These costs are listed in Table 3.

4.2 Schedule and Effort

The scintillator and light guides will be ordered when funds are available. The manpower needed to complete the hodoscope upgrade is estimated to be about 12 person-months. We believe most of the work can be completed within one summer with 4 or 5 Abilene undergraduate students and a supervising professor. Support for this group would be paid by from the DOE grant to the ACU particle physics research team.

4.3 Location

The photomultiplier quality control will take place at ACU during the school year. Due to the fragile nature of the glue joints and the large size of these counters (Station 4 in particular) it is expected that the assembly of the hodoscopes will be performed at Fermilab. We have asked Fermilab to provide appropriate space for this work. Travel funds for this work (both student and faculty) will be provided by Abilene's DOE grant.

Table 3 Material costs and effort for Station 3 and 4 hodoscopes.

			Effort (FTE)	
WBS	Description	Material Cost	Student	Senior Staff
2.1.3.1	Scint. Purchase	$110k	1 wk (QA)	
2.1.3.2	Light guide purchase	$29k	1 wk (QA)	
2.1.3.3	Hodoscope assembly	$2k	8 months	3 months
2.1.3.4	Hodoscope installation	$10k	3 months	
2.1.3.5	Final Testing		1 month	
Totals		$151k	12.5 months	3 months